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Report of the Cod Mixing Workshop

16-17 October 2000
Airport Plaza Inn
St. John's, Nfld.

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Table of Contents

Abstract / Résumé..... 4

I - Introduction..... 5

II - Background and analyses..... 5

III - General Discussion - Implications for the 3Ps and 3Pn 4RS cod assessments and management..... 13

IV- Potential Further Research..... 15

Annex I: Agenda for the Cod Mixing Workshop, 16-17 October 2000, Salon A, Airport Plaza Inn, St. John's, Nfld..... 16

Annex II: Chart of the Gulf of St. Lawrence and the Laurentian Channel showing NAFO Divisions, unit areas and place names mentioned in the text. 17

Annex III: List of Participants to the Cod Mixing Workshop..... 18

Abstract

A workshop to examine the issue of cod mixing in relation to the 3Pn4RS and 3Ps cod stocks was held in St. John's, Nfld. on October 16 and 17, 2000. The meeting was organized in response to concerns that mixing between these two cod stocks during the over-wintering period impact both the stock assessments and the management of these stocks. The purpose of the meeting was primarily to examine new analyses of the issue and to determine: 1) whether changes needed to be incorporated in the fall 2000 3Ps stock assessment and the winter 2001 northern Gulf assessment and, 2) whether there are management implications for the upcoming fishing seasons. The results of the analyses indicated that there is mixing, between the two stocks. It was suggested that the usual assessments are conducted for the two stocks but that scenarios that take into account mixing be also examined. The results from these scenarios would be described in the stock status reports to provide possible indication of the uncertainties associated with the mixing of the two stocks. In terms of management of these fisheries, it was concluded there are several potential solutions and examples were provided. It was concluded that the best way to develop conservation measures relative to this issue was by an iterative consultation process of all stakeholders.

Résumé

Un atelier pour examiner la question du mélange des stocks de morue de 3Pn4RS et de 3Ps s'est tenu à St. John's (Terre-Neuve), les 16 et 17 octobre 2000. La réunion a été organisé en réponse à des inquiétudes que le mélange de ces stocks lors de la période d'hivernage pourrait avoir des impacts à la fois sur l'évaluation et la gestion de ces deux stocks. Les objectifs de la réunion étaient principalement d'examiner de nouvelles analyses sur le sujet et de déterminer: 1) si des modifications doivent être apportées aux évaluations à l'automne 2000 pour le stock 3Ps et en hiver 2001 pour le stock 3Pn4RS et 2) s'il y a des implications pour la gestion de ces pêcheries lors des prochaines saisons de pêche. Les résultats des analyses ont indiqué qu'il y a mélange entre les deux stocks. On a suggéré d'effectuer les évaluations pour les deux stocks de la façon usuelle mais aussi d'examiner des scénarios qui tiennent en compte le mélange des deux stocks. Les résultats de ces analyses seraient présentés dans les rapports sur l'état de ces stocks afin de donner une indication des incertitudes potentielles associées à ce mélange. En ce qui a trait à la gestion de ces stocks, on a conclu qu'il existe plusieurs solutions potentielles et des exemples ont été présenté. On recommande que le meilleur moyen d'arriver à des mesures de conservation en relation à cette question est par un processus itératif de consultation avec tous les intervenants.

Report of the Cod Mixing Workshop
16-17 October 2000,
Salon A, Airport Plaza Inn, St. John's, Nfld.

I – Introduction

A workshop to examine the issue of cod mixing in relation to the 3Pn4RS and 3Ps cod stocks was held in St. John's, Nfld. on October 16 and 17, 2000. The final agenda for the meeting is presented in Annex I. A chart of the areas, including place names mentioned in the text can be found in Annex II.

The meeting was organized in response to concerns that mixing between the 3Pn4RS and 3Ps cod stocks during the over-wintering period impact both the stock assessments and the management of these stocks. The purpose of the meeting was primarily to examine new analyses of the issue. Based on the analyses presented, two questions were addressed:

- What are the changes that need to be incorporated in the upcoming 3Ps and northern Gulf stock assessments?
- Under a precautionary approach, are there management implications for the upcoming fishing seasons (April 1 for 3Ps, May 15 for 3Pn, 4RS) ?

The meeting was concluded by a discussion of potential research to elucidate the issue.

Participants to the workshop are listed in Annex III. The meeting adjourned at 17:15 on October 17.

II – Background and analyses

1) Mixing of 4T, 4Vn and 4VsW Cod stocks: A Review of the Scientific Basis and of Fisheries Management Actions - G.A. Chouinard

A review of the mixing issues in this area as well as the scientific studies conducted to examine them, along with the management actions arising from these analyses was presented as a background example from another area. Since the early 1990's, three issues relating to the management unit of the southern Gulf of St. Lawrence (4T-Vn) cod stock have been examined and management actions taken. First, it has long been known that southern Gulf (4T) cod overwinter in 4Vn. Given that cod from 4T were more numerous, catches in 4Vn in winter have always been attributed solely to the southern Gulf stock despite likely mixing with 4Vn resident fish. To prevent for the potential catch of the 4Vn resident stock, the winter fishery for 4T cod in 4Vn has remained closed in 1999-2000 despite re-opening in 4T. A study to determine whether the two stocks occupy exactly the same areas in winter is being undertaken. The second issue related to the timing of the migration of southern Gulf cod into 4Vn. Analyses indicated that southern Gulf cod migrate in 4Vn in November. As a result the management unit was changed from 4T-4Vn (January-April) to 4T-4Vn (November-April). Finally, in the

early 1990's, it was discovered that 4T cod had an extended migration in 4Vsb (immediately south of 4Vn). To avoid un-planned exploitation of southern Gulf cod, directed fisheries for cod in 4Vsb have been prohibited since 1993.

2) Recap of Minutes of 1998 Halifax Meeting on the Cod Mixing Program and of Relevant 1999 Rimouski ZAP Meeting - M. Castonguay

a) Recap of recommendations of 1998 meeting of the cod stock mixing HP program

- "Improved management under the *status quo* would require a rapid form of forensic stock determination in the mixing area of 3Ps and 4Vs such that commercial catches could be assigned to the appropriate stock. Such a method may now be available, but its cost-effectiveness would need to be established.
- A second approach to avoiding over-exploitation of 3Pn4RS cod given their presence in the Burgeo Bank area of 3Ps would be to close this area to fishing in the winter and early spring. Similar actions have already been implemented in the 4Vsb management area.
- Another approach would be to use a fixed mixing ratio of 3Pn4RS and 3Ps cod, based on the results of this project. Seasonal and spatial quotas for the two stocks could then be adjusted accordingly. Under this approach, assumptions concerning the change in mixing ratio across months would be required, as would across-year changes in the ratio due to changes in relative abundance.
- A fourth approach would be to adjust the assessment and management units to include the Burgeo Bank and adjacent area (winter) within the 3Pn4RS assessment/management unit. Such an approach has already been adopted to compensate for the migration of 4TVn cod into the 4Vs area, and should improve the precision of stock abundance estimates for both the 3Pn4RS and 3Ps resources.
- The annual RV survey in support of the 3Ps cod assessment is carried out in April. It is not clear that all 3Pn4RS cod have left the 3Ps mixing area by this time. While acknowledging that a delay in the timing of the entire 3Ps survey to later in the spring may confound efforts to estimate 3Ps cod abundance before any inshore migration, there may be benefits to delaying the survey of the Burgeo Bank region to the latter part of April."

b) Recap of 1999 Rimouski ZAP meeting

- A conclusion of HP project: 3Pn4RS and 3Ps cod are found in a 3:1 ratio in the Burgeo/Hermitage area (3Psa+d) in winter.
- Conclusion was disputed by NF scientists because of inadequate sampling in 3Psa, and because method cannot distinguish possible Burgeo spawners that feed in the Gulf from Gulf spawners.
- Hence no change to assessment or management units were considered for 3Ps cod.

c) Recap of FRCC recommendations 1999 and 2000

"The winter fishery on Burgeo Bank should be closed from November 15 to April 15 to protect 4RS3Pn stock components"

d) Recap of management implementation of FRCC recommendation

- Incomplete implementation of FRCC's recommendation:
- Closure from Nov 15 to Apr 15 as recommended by FRCC, but for 3Psd only instead of closing both 3Psa and 3Psd as "Burgeo closure" suggests.

Discussion:

Most of the discussion of this presentation focused on whether this workshop should not be discussing the implications for management actions but rather examining the new scientific analyses.

The current management plan closes 3Psd but not 3Psa during the winter period. Although the majority of Burgeo Bank is in 3Psa, the majority of fish from Burgeo Bank taken in the winter commercial fishery have in the past been taken in 3Psd. A 3Psa closure would close the inshore longline fishery that has traditionally been conducted in the winter, shoreward of Burgeo Bank in this management unit. It appears clear that the current management units are not defined on any biological basis and that an attempt should be made to better define the areas/times affected by mixing.

3) Integrated Stock Mixture Analysis (ISMA) of Overwintering Cod in and Around the Gulf of St. Lawrence Based on Otolith Elemental Fingerprints, Microsatellite DNA and Vertebral Counts - S. Campana, K. Frank, S. Smith, G. Chouinard, D. Swain, C. Taggart, D. Ruzzante, D. Cook

Elemental, genetic and meristic markers were used to identify the cod stocks of the Gulf of St. Lawrence and its approaches, determine the stock composition and geographic extent of the winter mixing zones, and assess the validity of the current cod management units. Synoptic research vessel surveys carried out each January between 1994-1997 documented dense aggregations of cod along both flanks of the Laurentian Channel, with estimated biomasses exceeding 100,000 t each year. Spawning stock identifiers based on otolith elemental fingerprints, microsatellite DNA and vertebral counts were all capable of distinguishing among the cod stocks in the area, although some methods were more sensitive than others. The large number of rare alleles, which may have distorted previous genetic analyses, complicated stock mixture analyses based on microsatellite DNA. A maximum likelihood-based integrated stock mixture analysis (ISMA) was developed to simultaneously analyze the otolith, DNA and vertebral stock marker data. In general, large-scale stock mixing was not evident; cod from the southern Gulf of St. Lawrence dominated the population composition along the southwestern flank of the Channel, while cod from the northern Gulf dominated the northern flank. There was little evidence of cross-channel mixing, and the contribution of 4Vn and 3Ps (particularly Fortune Bay and Placentia Bay) cod stocks to the survey region was minimal. There were significant

extensions of both the 4T and 3Pn4RS stocks into the neighboring management units to the southeast, specifically into 4Vs and 3Ps respectively, indicating that current assessment and management boundaries do not accurately reflect winter stock-specific distributions. The most substantive mixing zone was in 3Ps to the northwest of St. Pierre Bank where 3Ps cod made up less than 25% of the biomass.

Discussion:

The location of samples for reference spawning groups may cause some problem in this study as all of the offshore 3Ps samples have come from well south of 3Psa. However there were samples available from spawning fish on the top of St. Pierre Bank. There was also some discussion as to whether the spawning location of the reference spawning groups is actually known. The fish appeared to be in spawning condition at the time of sampling and in conducting this analysis one must assume that they are going to spawn where they were sampled. This same assumption would apply to all studies involving spawning fish.

At the time of the presentation of this paper fish that spawn on Burgeo Bank were not included in the stock mixing analyses. This would mean that the percentage of 3Ps fish in the area in January 1996 and 1997 is under estimated. An attempt was later made to include these fish in a stock mixture analysis. The stock mixture analyses presented for January 1996 and 1997 may not have extended far enough inshore to cover the winter fishery inshore of Burgeo Bank and thus is not applicable to the area inshore of Burgeo Bank area at this time of the year.

Vertebral analyses were very good at distinguishing populations when 4T fish dominated them. When the groups were more mixed the vertebral analysis performed poorly. The genetic analyses were affected by the presence of a number of rare alleles. Most of the conclusions were based on analyses that combined the vertebral, otolith and modified genetic analyses.

<u>Stock mixture analyses including Burgeo Bank - S.E. Campana</u>

When Burgeo Bank spawners were introduced into the ISMA reference set, the estimated contribution by Burgeo Bank spawners to the winter mixing area was negligible, suggesting that they were indistinguishable (both genetically and in terms of otolith elemental fingerprint) from adjacent areas. However, even if it was assumed that all Burgeo Bank resident cod were classified of being of 3Pn origin, the contribution of cod originating from 4R to the 3Ps winter mixture was 79% and 56% in 1996 and 1997, respectively.

Discussion:

As with the tagging studies, since fish that have not yet begun to spawn are included in the reference samples, it is possible that some of the fish in the reference spawning groups would actually spawn in another area.

The fact that the inclusion of the Burgeo Bank reference samples in the stock mixture analyses increased the percentage of 3Ps fish in the area but did not show up the Burgeo Bank as a separate group may indicate that the Burgeo Bank group is being classed with the 3Ps offshore group.

4) Results of tagging from Sentinel fisheries in the Gulf (3Pn, 4RS) - M. Bérubé and A. Fréchet

Results of an extensive recent tagging program were updated to examine the mixing in the Burgeo Bank area. Although this program was initially designed to examine possible relationships between inshore and deeper water cod within the 3Pn 4RS stock, it was found useful to address the mixing in the Burgeo Bank area.

Over 43 000 tags have been placed on cod within the last 6 years by both fixed and mobile gear sentinel fishers in the Gulf (3Pn, 4RS). Of these only 1 132 tags have been recaptured by July 2000 (141 in 3Ps and 8 in other stock areas – 4T, 4Vn and 3KL).

The examination of fish recaptured at least one year after tagging (irrespective of the tagging date) indicates an important movement from 4S towards 4R (57% of recaptures). Fish tagged in 4R were mostly recaptured in 4R (65%) but were recaptured in 3Pn and 3Ps in equal numbers(12% and 13% respectively). Finally, 63% of the cod tagged in 3Pn were recaptured in the area and 22% were recaptured to the east (3Ps).

Many recaptures from Gulf tagging were in inshore waters of 3Ps from inshore of Burgeo up to Placentia Bay. This new finding must be validated by maintaining tagging programs and targeting April-May period (spawning). No significant recaptures were made in adjacent stocks (4T-Vn [Nov.-Apr.]).

Discussion:

There are a number of winter recaptures in 3Ps from fish tagged in 3Pn4RS from April to October but it is important to keep in mind that there is no possibility of recaptures in 3Pn4RS in winter due to the absence of fishery there.

It was decided that winter recaptures from fish tagged in the Gulf in May and June and from May to July should be examined. This was done during the meeting, however the mixing among divisions did not change appreciably restricting the analysis to these months.

There was also a request to weigh recaptures by landings by unit area and month. This was done in a qualitative way (see further analyses below)..

In response to a question on whether cod in the Gulf in summer and fall are actually cod that had spawned there, it was concluded that it was not absolutely certain but evidence from tagging suggests that northern Gulf cod feed in the same area that they spawn.

Further Analyses on Tagging Data from 3Pn4RS - M. Bérubé and A. Fréchet

Another analysis was done by restricting the tagging period from May to June and from May to July as a proxy for the spawning period. Recaptures of 4R tagged fish into 3Ps decreased from 13 to 9% with the May-June restricted tagging period. Similarly, by restricting the tagging period, recaptures of 4S tagged-fish into 3Ps decreased from 4 to 0% and recaptures of 3Pn tagged fish decreased from 22 to 11%.

Discussion:

When only data from tags put on in May to June are included then the percentage of returns in 3Ps is around 9-11% for fish tagged in 4RS3Pn. This does not take into account the difference in catch between 4RS3Pn and 3Ps. The larger 3Ps catch compared to 4RS3Pn will tend to bias upward the recapture rate in 3Ps.

There are no estimates of reporting rate for these tags from recaptures in 3Ps. There is a lower reporting rate for fish tagged in 3Ps and recaptured in 3Pn4RS than for those recaptured in 3Ps.

5) Spatial patterns in cod maturity data from recent April surveys - J. Brattey and D. Stansbury.

Data on maturation stages of cod sampled during recent (1996-2000) April surveys of cod in NAFO Subdivisions 3Ps and 3Pn were examined to look for spatial or temporal trends in maturation and spawning. Cod gonads were examined visually at the time of capture and classified in the standard manner as maturing (AP), spawning (BP, CP and partly spent) or spent. The numbers of cod per tow at various stages of maturation were overlaid on maps of 3Ps as a series of expanding symbol plots to show exact locations and numbers of males and females at these various stages of maturation. In most years the number of sets with large numbers (>50) of adult fish in either of the maturity stages was small, and these large sets were generally restricted to the southern or western side of Burgeo Bank, western 3Pn, or Halibut Channel. There were a few sets with considerable numbers (>15) of spawning males on Burgeo Bank in 1996, 1998, 1999 and 2000. There were a few sets with considerable numbers of spent females on Burgeo Bank in 1996 and 1998. There were no large sets of adult fish anywhere in the central portion of 3Ps across the middle of St. Pierre Bank or at the mouth of Placentia Bay. There were no sets in any of the years with large numbers of females at stages Mat BP, Mat CP, or partly spent; this may be partly due to the short duration of these stages. The rest of the females were maturing.

Bar charts were also prepared showing annual proportions of adult female fish at various stages of maturation in three regions of 3Ps (Burgeo-Hermitage Channel, mid-3Ps, and southern 3Ps) from 1983 to 2000. These maturity data came from fish sampled for age during the 3Ps surveys. The proportion of spawning and spent females in the Burgeo-Hermitage area in the most recent year (1993-2000) when surveys were conducted in April was variable but averaged about 25%. The majority (75%) of the females were

maturing. The results indicate that spawning occurs in the Burgeo area in April in most years.

Cod discards collected during tagging studies conducted at the mouth of Hermitage Channel in the first week of April in 1998 and 1999 were also sampled for maturity stages. The proportion of spent fish was extremely high (90%) in 1999, but low (10%) in 1998.

Discussion:

The restricted distribution of spawners was of concern. As was the case with the tagging and other studies, it was possible that individuals close to spawning would actually spawn elsewhere, including batch spawning at various locations across the 3Ps-3Pn line. Finally, it was noted that the location of spawning males is not a good indicator of spawning grounds, since they remain in spawning condition for an extended period of time.

6) Information on mixing from tagging - J. Brattey and N. Cadigan.

Tagging studies have been conducted on cod in the Burgeo area (3Psa and 3Psd) of subdivision 3Ps during winter and spring on several occasions since the 1950's. For all of these studies, conducted in the 1950's, 1960's, 1980's, and late 1990's, recaptures were tabulated by unit area and in all of them substantial numbers of tagged fish were recaptured eastward along the south coast in 3Ps as well as northward into the adjacent management unit 3Pn4RS. The precise stock origins of these tagged fish were not defined but the studies were conducted during March-June when spawning takes place and the tagging was likely to include 3Ps fish.

At the request of the meeting, the recaptures from tagging experiments in 1998 and 1999 were adjusted by removing all recaptures within the first 3 months after release. This substantially reduced the numbers of recaptures, even in unit areas considerable distances away from the tagging site. For the 1998 and 1999 studies the recaptures were further weighted by tag reporting rates calculated from a high-reward tagging study. In addition, the number of tags from each unit area was standardized by dividing the numbers by the cumulative post-tagging catch for the corresponding unit area (tags from first three months after tagging removed). For the 1998 experiment conducted in early April, this resulted in about 7-8 times as many recaptures from 3Pn4RS compared to 3Ps. For the 1999 tagging the standardized tagging recapture rates were slightly higher in 3Ps, but the results were based on few recaptures (10) and not considered further. In interpreting these results the standardized recapture rate of tagged fish can be strongly influenced by the relative proportions of untagged fish from other areas that contribute to catches. The lower standardized catch rates within 3Ps compared to 3Pn4RS may be partly due to the larger stock size within 3Ps. However, even allowing for these differences the results suggest that the majority of the tagged fish migrated into the 3Pn4RS area although exact proportions could not be determined.

Results of recent (1998, 1999) tagging studies in early spring in Placentia Bay, Fortune Bay, and Halibut Channel were also presented in the form of distribution maps of recaptures and these revealed few or no recaptures westward toward the mixing area.

Discussion:

It is important to keep in mind that catches were several times higher in 3Ps than in 3Pn4RS in the years where the recent Burgeo tagging experiments were conducted and this will tend to bias downward the Gulf contribution to recaptures. However, adjustments for this effect to the weighted tag recoveries did not change the conclusion that substantially more fish tagged on Burgeo in early April were later recaptured in the northern Gulf than in 3Ps.

7) Migration model from tagging results Noel Cadigan

A model is presented to estimate exploitation rates (fraction of stock removed by the fishery) using tags returned from the commercial fisheries for Atlantic cod in NAFO Divisions 3L and 3K (3KL), Subdivisions 3Ps and 3Pn, and Divisions 4R and 4S during 1997-1999 (March). The tag-returns are from numerous tagging experiments conducted in these areas during 1997-1999. Over 36 000 cod in total have been tagged and released during 1997-2000 and 4900 of these have been reported as recaptured. The model has the potential to estimate weekly exploitation rates in many regions around the inshore coastal regions of Newfoundland. The exploitation rates are length and gear specific. The model also has the potential to estimate migration rates. Emigration of tagged fish complicates the analysis of tag-returns, and can result in underestimation of exploitation rates. Some practical problems involved in estimating the model parameters are the lack of tagging in some regions and years, and the lack of fishing (source of tag returns) in some regions and years.

Discussion:

In response to a question on division-specific tag reporting rates, it was indicated that the reporting rates were calculated by comparing the return rates of a program with a high reward and those from the regular tagging program.

8) Age compositions in sentinel surveys - G.R. Lilly

The inshore catches from the sentinel line trawl surveys in 3Psa were dominated in 1995 and 1996 by the 1989 and 1990 year classes, two year-classes that were not dominant in the 3Pn4RS population but were dominant in the rest of 3Ps. The dominance of these two year-classes in 3Psa was consistent among months (Feb – Dec) in 1995, the only year with consistent seasonal sampling and across years (1995 and 1996) in the fall (Sept.-Dec.).

Discussion:

It is possible that the larger fish move out of the Gulf earlier than the younger smaller fish. These fish may be then caught in the commercial fishery in 3Ps. However, the dominance of the year classes over the entire year should mean that at the most only a portion of the catch could be from 3Pn4RS.

There were no offshore samples available from these years for these periods, therefore the expected difference in age composition could not be confirmed. The age composition of the 1996 and 1997 HPF samples were not similar to the age composition pattern noted in the inshore analysis.

9) A review of the sensitivity of Burgeo Bank catch and survey index on an ADAPT based assessment of the cod stock in NAFO Subdivision 3Ps – D. Stansbury

The presentation was one that had been made at the March 1999 ZAP meeting in Rimouski. It examined the impact of mixing on assessment results with various assumptions of catch and survey index including and excluding the estimated contribution of 3Pn 4RS cod in the Burgeo Bank area in winter. Results indicated that the trends in population abundance were similar but that terminal estimates of biomass differed by 20% between the two extreme cases. Excluding 3Pn 4RS cod estimated in winter on Burgeo from both the catch at age and survey index resulted in the lower terminal estimate.

III - General Discussion - Implications for the 3Ps and 3Pn 4RS cod assessments and management

a) What are the changes that need to be incorporated in the up-coming 3Ps and northern Gulf stock assessments ?

The discussion started with a definition of which fish are included in a given stock. Generally, it is defined that it is those fish that are spawning in the given area (e.g. 3Ps cod would be comprised of fish that spawn in 3Ps whether or not they spend all their time there). It was recognized that there are often overlaps in the distribution of stocks at other times of the year, some more important than others.

Given the results of the integrated analysis of trace elements, genetics and vertebral count and the results of the tagging experiments, which suggest mixing between the two stocks, it was suggested that the usual assessment be conducted for 3Ps but that three other scenarios be conducted. They would include:

1) Total catch less 75% of catches on Burgeo from November 1 – April 30 with RV abundance index. (Burgeo strata currently removed from winter survey)
2) Total catch and RV abundance index with Burgeo strata removed from all surveys (1983-84; 1993-2000)

3) Total catch less 75% of catches on Burgeo from November 1-April 30 and RV abundance index with Burgeo strata removed from all surveys (1983-84; 1993-2000).

(Note: 75% was in the range of the values estimated to originate from the 3Pn4RS cod in the Burgeo samples from January 1996-1997 of the integrated analyses

For the 3Pn 4RS assessment, similar analyses would be conducted. The scenario based on the conclusion that cod from the stock are found on Burgeo Bank in winter would result in including 75% of the estimated catches from the Burgeo area of 3Ps (3Psa and 3Psd) between November 1 and April 30 in the catch at age. It was noted that no change would be required for the abundance index.

The results from these scenarios would be described in the stock status report to provide possible indication of the uncertainties associated with the mixing of the two stocks. It would be pointed out that the analysis may be biased because of potential catches of 3Ps cod in 3Pn 4RS.

b) Under a precautionary approach, are there management implications for the upcoming fishing season (April 1 for 3Ps, May 15 for 3Pn 4RS)?

The area of Burgeo Bank is recognized as a mixing area in winter where fish from 3Ps and 3Pn 4RS can be encountered. For the only two years where estimates were available, cod of 3Pn4RS origin were estimated to be present in a 3:1 ratio relative to 3Ps cod in January. Fisheries management needs to be concerned with removals in the area as it may result in over-exploitation of the northern Gulf stock. There are several potential approaches to the issue. Examples include, but are not limited to: a) re-defining the stock unit as 3Pn3Ps(a and d ; Nov-Apr)4RS b) closing the fisheries in 3Ps (a and d from Nov to April) c) accounting for the fact that catches of 3Pn4RS are taken outside the management unit by reducing future TACs in 3Pn4RS d) more precisely defining the geographic area of most likely mixing and closing only this area to fishing in winter.

It was recommended that the best way to develop conservation measures relative to this issue was by an iterative consultation process between scientists, fisheries managers and the industry. In such a process, management measures could be suggested by fisheries managers and the impact of these relative to the mixing issue would be assessed by DFO Science. This process would take some time but is more likely to result in acceptable measures that also address the conservation objectives.

IV- Potential Further Research

1) Research possibilities to further our understanding of 3Pn4RS / 3Ps cod winter mixing – M. Castonguay

1. Possible Trace Element Project

- Conducting a trawl survey in February using Sentinel and/or DFO vessels in 3Pn and 3Ps planned jointly by Mont-Joli and St. John's scientists for the purpose of analyzing trace element composition of otoliths on sub-samples of fish.
- If possible, tagging could also be conducted as part of this survey.
- Mixing would need to be reassessed periodically, say every 3rd year.

2. Possible Historical Trace Element Project

Going through historical otolith databases from 3Ps, assess mixing using the trace element method.

3. Possible Telemetry Project

- Putting a line of receivers along 3Pn/3Ps line (70 mile) to monitor movements of 3Pn4RS cod equipped with pingers across the line.
- Such work is already being done successfully on a small scale in LaPoile, SW NF.
- Such work has also been undertaken on a large scale to monitor movements of 4Vn cod off Sydney Bight. This could be possibly be repeated here using some of the same equipment.

Such a project would provide different but complementary information to a trawl survey. It would not provide information on easterly extent of 3Pn4RS mixing into 3Ps. But it would shed light on fraction of 3Pn4RS stock overwintering in 3Ps.

Discussion:

Discussion on this topic was limited and the presentation was meant to present some ideas to elucidate the issue of mixing in the 3Ps area. Other ideas could be examined. Collaboration between the Laurentian and Newfoundland Regions to conduct further research is encouraged.

Annex I: Agenda for the Cod Mixing Workshop, 16-17 October 2000, Salon A, Airport Plaza Inn, St. John's, Nfld.

I – Background and analyses

1. Mixing of 4T, 4Vn and 4VsW cod stocks: a review of the scientific basis and of fisheries management actions - G.A. Chouinard

2. Recap of minutes of 1998 Halifax meeting of the cod mixing program and of relevant1999 Rimouski ZAP meeting – M. Castonguay.

3. Integrated stock mixture analysis (ISMA) of overwintering cod in and around the Gulf of St. Lawrence based on otolith elemental fingerprints, microsatellite DNA and vertebral counts – S.E. Campana, K. Frank, S. Smith, G. Chouinard, D. Swain, C. Taggart, D. Ruzzante, D. Cook

4. Tagging information on 3Pn, 4RS cod – M. Bérubé and A. Fréchet

5. Spatial patterns in cod maturity data from recent April surveys and tagging results from 3Ps– J. Brattey

6. Information on mixing from tagging –N. Cadigan

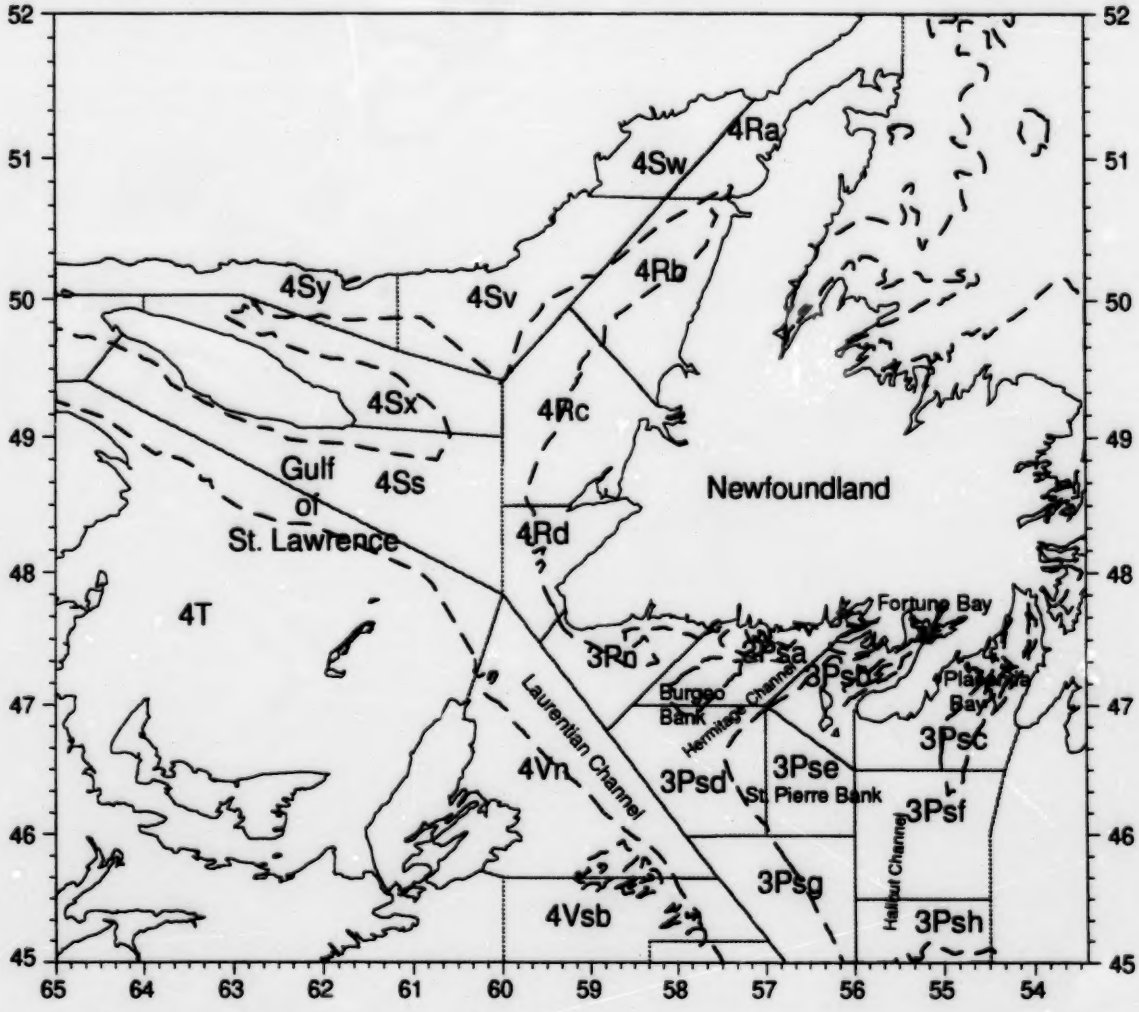
II – Implications for the 3Ps and 3Pn 4RS cod assessments and management

Once all analyses have been reviewed, a discussion of the issue is required to address two main points:
- Based on the analyses presented, what are the changes that need to be incorporated in the up-coming 3Ps and northern Gulf stock assessments?
- Under a precautionary approach, are there management implications for the upcoming fishing season (April 1 for 3Ps, May 15 for 3Pn 4RS)?

III – Potential Further Research

1. Research possibilities to further understanding of 3Pn4RS /3Ps cod mixing – M. Castonguay

Annex II: Chart of the Gulf of St. Lawrence and the Laurentian Channel showing NAFO Divisions, unit areas and place names mentioned in the text.



Annex III: List of Participants to the Cod Mixing Workshop

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